

**REVIEW**

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**MISSION OPERATIONS AND DATA SYSTEMS DIRECTORATE**

**Earth Science  
Data and Information System (ESDIS)  
Level 1 Product Generation System (LPGS)  
Release Implementation Plan**

**August 1997**



National Aeronautics and  
Space Administration

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Goddard Space Flight Center  
Greenbelt, Maryland

## REVIEW

# Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Release Implementation Plan

August 1997

Prepared Under Contract NAS5-31000/HQ001057  
By Computer Sciences Corporation  
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### Prepared by:

\_\_\_\_\_  
D. Derrick Date  
LPGS Technical Manager, CSC

### Approved by:

\_\_\_\_\_  
D. Badolato Date  
LPGS Software Development Manager,  
GSFC, Code 551

### Reviewed by:

\_\_\_\_\_  
R. Hamilton Date  
LPGS System Engineer, CSC

\_\_\_\_\_  
J. Henegar Date  
LPGS Project Manager,  
GSFC, Code 514

\_\_\_\_\_  
J. Pizzola Date  
LPGS Project Manager, CSC

### Quality Assured by:

\_\_\_\_\_  
S. Whisonant Date  
Quality Assurance Officer,  
Landsat 7 Project, CSC

**Goddard Space Flight Center**  
Greenbelt, Maryland

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## Preface

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This document contains the software release implementation plan that defines the incremental buildup of functionality for the Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS). The allocation of software to releases is based on an analysis of the requirements contained in the

- LPGS Functional and Performance Requirements Specification
- Related interface control documents (ICDs)
- LPGS System Design Specification
- LPGS Detailed Design Specification

This document was prepared by

Computer Sciences Corporation  
7700 Hubble Drive  
Lanham-Seabrook, MD 20706

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### Abstract

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This document contains the software release implementation plan that defines the incremental buildup of functionality for the Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS). The allocation of software to releases is based on an analysis of the requirements contained in the LPGS Functional and Performance Requirements Specification, related interface control documents (ICDs), and the LPGS design presented in the LPGS System Design Specification and LPGS Detailed Design Specification documents. The availability of candidate software for reuse, including software from other Landsat 7 ground system elements [e.g., Landsat Processing System (LPS) and Image Assessment System (IAS)], and the sizing of new software were considered in allocating software to releases.

**Keywords:** *Earth Observing System Data and Information System (EOSDIS), Earth Resources Observation System (EROS), Earth Science Data and Information System (ESDIS), EDC Distributed Active Archive Center (EDC DAAC), EOSDIS Core System (ECS), EROS Data Center (EDC), Landsat 7, Level 1 Product, Level 1 Product Generation System (LPGS), Mission Operations and Data Systems Directorate (MO&DSD), Mission Operations and Systems Development Division (MOSDD), Systems Management Policy (SMP)*

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## Section 1. Introduction

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### 1.1 Purpose

The Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Release Implementation Plan documents the system release approach that will be used by the Mission Operations and Systems Development Division (MOSDD) of the Mission Operations and Data Systems Directorate (MO&DSD) at the National Aeronautics and Space Administration's (NASA's) Goddard Space Flight Center (GSFC) in implementing the subsystems of the LPGS.

The system release approach is an incremental approach to implementing, integrating, and testing systems. As the system is developed, each successive release adds to the system functionality provided in previous releases. Release 1 of LPGS will implement the Earth Observing System Data and Information System (EOSDIS) Core System (ECS)/LPGS interface and the automatic generation of a level 1 product. Release 2 will focus on the manual override options of LPGS, the disk maintenance functions, and the remaining LPGS external interfaces. Release 2 will implement the remainder of the requirements detailed in the baselined version of the LPGS Functional and Performance Requirements Specification (Reference 1), the ECS/Landsat 7 interface control document (ICD) (Reference 2), the Image Assessment System (IAS)/LPGS ICD (Reference 3), and the ECS/LPGS ICD (Reference 4), applicable to LPGS.

This plan describes the system release approach that will be used to implement the LPGS. This plan provides a detailed definition of the requirements and functions allocated to each release, and it maps software units to each release. It also presents the release implementation schedule necessary to support Landsat 7.

### 1.2 Applicable Documents

The following documents contain background and/or detailed information that was referenced in creating the LPGS Release Implementation Plan.

1. National Aeronautics and Space Administration (NASA), Goddard Space Flight Center (GSFC), 510-FPD/0196, *Level 1 Product Generation System (LPGS) Functional and Performance Requirements Specification*, February 1997
2. Hughes Information Technology Systems, 209-CD-013-003, *Interface Control Document Between EOSDIS Core System (ECS) and the Landsat 7 System*, March 1996
3. NASA, GSFC, 514-4ICD/0197 (CSC 10037996), *Interface Control Document Between the Image Assessment System (IAS) and the Level 1 Product Generation System*, Review, August 1997
4. Hughes Information Technology Systems, 209-CD-029-001, *Interface Control Document Between the EOSDIS Core System (ECS) and the Level 1 Product Generation System*, Draft, June 1997



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5. NASA, GSFC, 510-4DDS/0197 (CSC 10038085), *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Detailed Design Specification*, Review, August 1997
6. —, *Level 1 Product Generation System (LPGS) System Integration and Test Plan*, August 1997
7. —, 505-10-23, *ESDIS Security Policy and Guidelines*, March 1996
8. —, 9NHB2410-9A, *NASA Automated Information Security Handbook*, June 1993
9. —, 510-1IDD/0197 (CSC 10037648), *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) Interface Definitions Document (IDD)*, Review, August 1997
10. —, *Landsat 7 Image Assessment System (IAS) Release Implementation Plan*, April 1997
11. —, 510-4SDS/0196 (CSC 10034686), *Earth Science Data and Information System (ESDIS) Level 1 Product Generation System (LPGS) System Design Specification*, March 1997

# Section 2. System Overview

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## 2.1 LPGS Objectives

The LPGS is an element of the Earth Observing System (EOS) Ground System (EGS). LPGS interfaces with the Land Satellite 7 (Landsat 7) System and other EGS elements.

The following are the primary objectives of the LPGS:

- To produce radiometrically and systematic geometrically corrected digital images of data collected by the Landsat 7 Enhanced Thematic Mapper Plus (ETM+)
- To provide radiometric characterization data to the Landsat 7 IAS

To meet these objectives, the LPGS must perform the following functions:

- Interface with the ECS to receive Level 1 product generation requests submitted to ECS by the user community
- Obtain from ECS the necessary Level 0R ETM+ data and ancillary files necessary to fulfill the product generation request
- Produce a consensus payload correction data (PCD) and mirror scan correction data (MSCD) file
- Apply the appropriate radiometric and geometric correction algorithms
- Transfer to ECS the requested Level 1 image in the user-requested format, along with the appropriate calibration parameter file, consensus PCD and MSCD file, and updated metadata file
- Capture and store, for periodic transfer to IAS, the characterization data generated by the radiometric processing algorithms

## 2.2 LPGS Subsystem Description

The LPGS capabilities are partitioned into seven subsystems. The following paragraphs describe the purpose and basic functionality of each subsystem. Two of these subsystems are black boxes in that the software is developed independently of LPGS, for use by LPGS and the Landsat 7 IAS. These black boxes are the radiometric processing subsystem (RPS) and the geometric processing subsystem (GPS). A more detailed description of each LPGS subsystem can be found in the LPGS Detailed Design Specification (Reference 5). Underlying these subsystems and supporting their functionality and interprocess communication is an Oracle database.

### Process Control Subsystem

With only a few exceptions, the process control subsystem (PCS) coordinates all processing within LPGS. It provides automated control of product request scheduling and processing. By

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default, PCS maintains first-in first-out processing of product requests. It also provides a manual capability for viewing and adjusting the LPGS production schedule.

PCS converts product requests into work orders. As needed, it automatically initiates, coordinates, and monitors work order processing. Additionally, PCS supports manual operations including visual quality assessment during generation of the Level 1 product.

### **Data Management Subsystem**

The data management subsystem (DMS) supports data formatting and external systems interfaces. The primary products formatted by DMS are the Level 1 product [in Hierarchical Data Format (HDF), Geographic Tag(ged) Image File Format (GeoTIFF), or Fast Argonne System for Transport, Format C (FAST-C), an output format for L1 digital images] and the consensus PCD and MSCD files. DMS controls the LPGS electronic interfaces with IAS and ECS. LPGS provides characterization statistics to IAS to support IAS's calibration efforts. DMS receives product requests and LOR files from ECS. For each successfully processed product request, DMS provides the properly formatted level 1 image and additional supporting data to ECS. It is also responsible for automatically deleting files after they have been successfully transferred to the ECS.

### **Radiometric Processing Subsystem**

The radiometric processing subsystem (RPS) provides all functionality required for Level 1R product generation, radiometric calibration, and radiometric characterization and evaluation. This subsystem implements all of the LPGS radiometry algorithms.

### **Geometric Processing Subsystem**

The geometric processing subsystem (GPS) provides all functionality required for Level 1G product generation, geometric calibration, and geometric characterization and evaluation. This subsystem implements all of the LPGS geometry algorithms.

### **Quality Assessment Subsystem**

The quality assessment subsystem (QAS) performs automatic quality assessment of Level 1R and Level 1G images. Using a combination of Level 1R thresholds and characterizations, QAS conducts the Level 1R quality assessment immediately following completion of radiometric processing. Similarly, using Level 1G thresholds, the Level 1G assessment is done immediately following completion of geometric processing. In each case, a quality report is produced by QAS and stored as an intermediate work product. QAS also provides the option for a manual visual quality assessment of a Level 1R or Level 1G image. Additionally the QAS subsystem supports the visual quality assessment of the Level 1 product after it has been placed in its final HDF, GeoTIFF, or FAST-C format.

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### **Anomaly Analysis Subsystem**

The anomaly analysis subsystem (AAS) provides the tools required by the LPGS analyst to resolve internal

LPGS anomalies, resulting from processing failures and trouble tickets assigned to LPGS by ECS. AAS supports the LPGS analyst by providing benchmark tools for confirming the integrity of the LPGS configuration. Additionally, AAS provides utilities to view all input received from ECS, as well as to review radiometric and geometric processing inputs, intermediate products, and results. Through AAS, the analyst is provided with the tools to display Level 0R, Level 1, and intermediate images. The AAS subsystem maintains an anomaly status table and generates anomaly reports.

### **User Interface**

The user interface (UI) is designed to support the job requirements of LPGS operations personnel. In the case of LPGS, this means that two distinct user interfaces are provided—one for the LPGS operator functions, and another for the LPGS analyst functions. The operator user interface (OUI) is provided through Oracle Forms. The analyst user interface (AUI) is provided through Oracle Forms and a commercial off-the-shelf (COTS) package for viewing images. Both interfaces allow the user to select functions to be performed.

## **2.3 LPGS Implementation Responsibilities**

The LPGS “infrastructure” subsystems—PCS, DMS, QAS, AA, and UI—are being developed by CSC and Code 551 personnel in support of GSFC Code 514. The RPS is being developed by the Algorithm Implementation Team (AIT), an integrated product team of personnel from GSFC, CSC, Century Computing, MindBank, and SGT, Inc. The GPS is being developed by the IAS Project at the EROS Data Center (EDC) in Sioux Falls, SD.

# Section 3. Release Plan

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## 3.1 LPGS Release Capability Summary

The LPGS will be implemented in two releases. Release 1 of LPGS will implement the ECS/LPGS interface and the automatic generation of a Level 1 product. Release 2 will focus on the operator override options of LPGS, the disk maintenance functions, and the remaining LPGS external interfaces. The functions developed in each release are summarized in Table 3-1. Appendix A maps LPGS system requirements to the releases. Appendix B lists the lines of code estimates for each release. Appendix C maps the units to each release.

Release 1 provides the capabilities to produce a level 1 product. LPGS capabilities implemented in Release 1 include functions for ingesting data from ECS, conversion of product requests to work orders, automatic scheduling of work order processing, invocation of radiometric and geometric processing, automatic quality assessment, and a minimal operator/analyst user interface. In addition, capabilities allocated to the COTS products within AAS will be provided to support Level 0R and Level 1 dataset display.

Release 1 of LPGS focuses on requirement 3.1.11 (unattended operations, i.e., no human intervention in the generation of the Level 1 product). Therefore, minimal user interface screens will be developed in Release 1 of LPGS. Release 2 is when the full complement of user interface screens will be put into place.

Release 2 completes the functionality of the LPGS. The LPGS is expanded to include the full complement of process control, data management, quality assessment and user interface capabilities, as well as custom anomaly analysis tools. The LPGS interface with IAS, as well as any interactions with the ECS Trouble Ticket system, are implemented in Release 2. The operator/analyst user interface is completed. Release 2 provides the operator override capabilities and other non-nominal functions.

## 3.2 LPGS Release Schedule

Table 3-2 is the LPGS schedule from the beginning of Release 1 implementation through LPGS site installation in the EDC Distributed Active Archive Center (DAAC).

## 3.3 Resources Required

This section describes the system hardware, allocation of major COTS software, and test resources for the LPGS implementation.

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**Table 3-1. Function Allocation to Releases**

Subsystem	Release 1	Release 2
Process control	Start up LPGS	Support manual overrides
	Automatically schedule work order	Support non-nominal processing
	Automatically process work order	Generate LPGS processing statistics
Data management	Ingest Level 0R products from ECS	Manage disk space
	Quality assess Level 0R products; generate consensus PCD and MSCD	Interface with IAS
	Generate Level 1 product in HDF-EOS and GeoTIFF formats	Generate Level 1 product in FAST-C format
Quality assessment	Provide Level 1 products to ECS	Record ECS interface statistics
	Automatic quality assessment of image immediately following radiometric and geometric processing	Visually assess image immediately following radiometric and geometric processing
		Visually assess formatted, Level 1 product
Anomaly analysis	Provide tools for examining contents of input, intermediate, and output files	Perform anomaly analysis of trouble tickets
User interface	Provide partial operator and analyst interface	Provide operator and analyst interface
Radiometric processing	Detect Level 0R image artifacts (striping, banding, coherent noise, scan correlated shift, saturated detectors, dropped scan lines)	
	Characterize Level 1R image (striping, banding, coherent noise, saturated detectors, dropped scan lines)	
	Correct Level 1R image (striping, banding, coherent noise, memory effect, scan correlated shift, inoperable detectors, saturated detectors, dropped scan lines)	
	Generate Level 1R image (apply radiometric correction)	
Geometric processing	Generate Level 1G image (create and initialize model, generate systematic grid, resample and create systematic image)	

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**Table 3-2. LPGS Implementation Schedule**

Planned Start	Planned Finish	Description
08/19/97	04/20/98	Release 1
08/19/97	01/26/98	Release 1 Implementation
01/26/98	03/09/98	Release 1 System Integration
03/09/98	04/20/98	Release 1 System Test
	04/20/98	Release 1 Completed
01/26/98	07/20/98	Release 2
01/26/98	04/20/98	Release 2 Implementation
04/20/98	06/01/98	Release 2 System Integration
06/01/98	07/20/98	Release 2 System/Factory Acceptance Test
	07/20/98	Release 2 Completed
07/20/98	08/20/98	EDC Site Installation
08/20/98	TBD	EDC Site Acceptance Test

**NOTE:** System testing and factory acceptance testing occur simultaneously for Release 2.

### 3.3.1 LPGS System Hardware

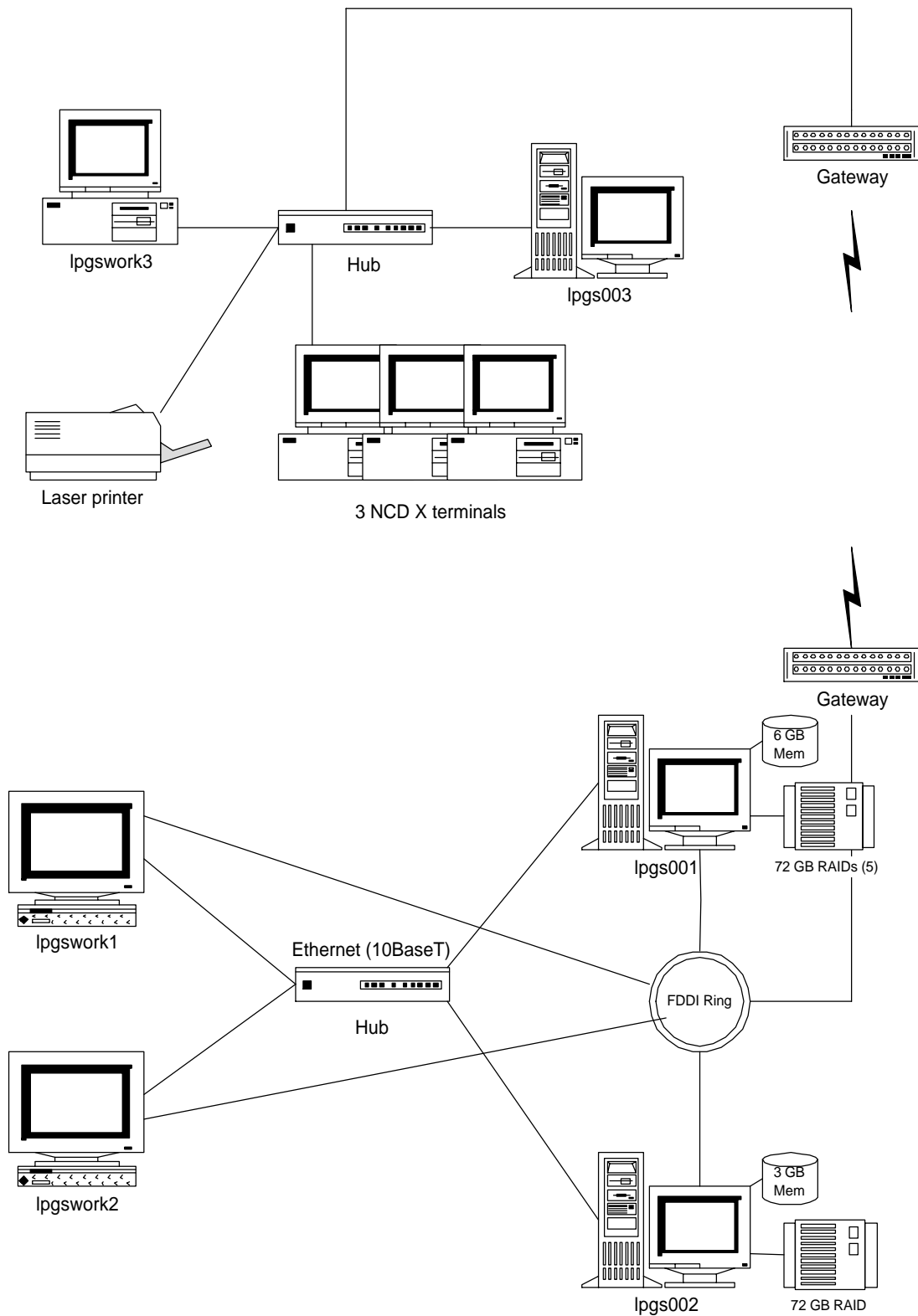
Figure 3-1 shows the LPGS development environment, including elements resident at GSFC and CSC's GreenTec IV facility.

Elements lpgs001 and lpgs002 are SGI Origin 2000s, and lpgs003 is an SGI Origin 200. Element lpgs001 has 4 processors and 6 gigabytes (GB) of memory, element lpgs002 has 4 processors and 3 GB of memory, and element lpgs003 has 4 processors and 256 kilobytes (kB) of memory. Elements lpgs001 and lpgs002 will be located at GSFC Building 23, and element lpgs003 will be located at the CSC GreenTec IV facility. They are allocated for software development and for system test throughout the development and system testing process.

LPGS analyst workstations (lpgswork1, lpgswork2, and lpgswork3) are SGI 02 workstations that will be used operationally for image evaluation and analysis. Two of these workstations are located at GSFC Building 23, and the third is located at the CSC GreenTec IV facility. These systems are available for software development through the entire development process. One of two of these systems will be allocated for system test following the delivery of Release 1 from the Development Team to the System Test Team. In addition, there are 3 NCD X terminals located at the CSC GreenTec IV facility used in a shared development environment.

The LPGS hardware is accessible to the implementation and test teams, 24 hours a day, 7 days a week. Access on evenings and weekends is provided by a few keys. Development terminal, printers, and network connections are available to the LPGS team members at the CSC GreenTec IV facility and at GSFC.

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**Figure 3-1. LPGA Development Environment**



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### 3.3.2 Commercial Off-the-Shelf Software

Several COTS products will be procured to support software development or to provide LPGS system functionality. Table 3-3 allocates COTS licenses across the development computers. The table includes only COTS products procured by GSFC or CSC; it does not include COTS products procured by EDC or Hughes/STX (H/STX). The allocation is based on TBS assumptions.

### 3.3.3 Test Tools and Data

Raw wideband data will be obtained by reusing test data used by IAS.

Tools to dump data from shared memory and to produce formatted dumps of LPGS files will also be borrowed from the IAS and Landsat Processing System (LPS) Project.

Tools and data should be available for Release 1 testing. Both will be used for unit, module, subsystem and system test, and may be provided to the customer for acceptance and operational test use.

Test tools and data are addressed in more detail in the *Level 1 Product Generation System (LPGS) Integration and Test Plan* (Reference 6).

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**Table 3-3. COTS License Allocation**

Product	Vendor	Total Copies	lpgs 001	lpgs 002	lpgs 003	lpgs work1	lpgs work2	lpgs work3
<b>Analysis/Design</b>								
RTM Ver 3.5	Marconi							
Designer 2000	Oracle	Note 1						
Teamwork Ver 6.2	Cadre	35 (Note 2)						
<b>Software Development</b>								
Developer 2000	Oracle	Note 1						
Oracle Server	Oracle	Note 1						
SQL*Plus	Oracle	Note 1						
Pro*C Dev/KDebugger	SGI	20						
IDL Ver 5.0	RSI	2						
Purify Ver 4.0	Pure Software	20						
<b>CM Tools</b>								
RPS	Shareware							
PVCS Ver 5.2	Intersolv	3						
<b>Other Applications</b>								
TBD								

Note 1: All Oracle software is covered under the Landsat 7 site license.

Note 2: Exists on IPD Case; shared with LPS and IAS.

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### Appendix A. Mapping of Requirements to Releases

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The following table maps the requirements specified in the LPGS Functional and Performance Requirements Specification to the Releases in which the requirements are satisfied (i.e. fully testable). Some requirements are not allocated to software and therefore not mapped to software requirements.

Requirement Number	Requirement Description	Release 1	Release 2
3.1	System-Level Requirements		
3.1.1	The LPGS shall nominally generate Level 1 digital images on a first ordered, first processed (FIFO) basis.	X	
3.1.2	The LPGS shall provide the capability to move a Level 1 image processing work order within the FIFO queues according to operator direction.		X
3.1.3	Deleted		
3.1.4	Deleted		
3.1.5	The LPGS shall provide the capability to generate and report LPGS error messages.		X
3.1.6	The LPGS shall provide an interactive capability to facilitate detection and correction of abnormal system conditions.	X	
3.1.7	The LPGS shall provide the capability to isolate system faults.		X
3.1.8	The LPGS shall provide the capability to recover from system faults.		X
3.1.9	The LPGS shall provide the capability to test LPGS functions and external interfaces.		X
3.1.10	The LPGS shall provide the capability to support attended operations 24 hours per day, 7 days per week, on a continuous basis.		X
3.1.11	The LPGS shall provide the capability to support unattended, automatic processing 16 hours per day, 7 days per week, on a continuous basis.		X
3.1.12	The LPGS shall provide the capability to support Landsat 7 operations for a minimum mission life of 5 years.		X
3.1.13	The LPGS shall provide the capability to execute diagnostic tests for verifying proper operation of system capabilities and components.		X
3.1.14	The LPGS shall provide the capability to support end-to-end testing of Level 1 processing functions.		X
3.1.15	The LPGS shall provide the capability to control LPGS operations.	X	

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Requirement Number	Requirement Description	Release 1	Release 2
3.1.16	The LPGS shall provide the capability to monitor LPGS operations.		X
3.1.17	The LPGS shall provide the capability to reconfigure LPGS system resources.		X
3.1.18	The LPGS shall provide the capability to support software upgrades while supporting normal operations.		X
3.1.19	The LPGS shall be capable of making all software and databases used in operations accessible to ECS for archiving.		X
3.1.20	The LPGS design shall be scalable to allow for future growth in processing capability.		X
3.1.21	The LPGS shall be able to generate Level 1 digital images corresponding to either heritage Worldwide Reference System (WRS) scenes or to a partial ETM+ subinterval up to an area equivalent to three WRS scenes.	X	
3.1.22	The LPGS shall be capable of recovering from failures and aborts in a controlled manner.		X
3.2	External Interface Requirements		
3.2.1	The LPGS shall interface with the ECS to receive:		
3.2.1.1	LOR files (includes associated PCD, MSCD, and CPF)	X	
3.2.1.2	Level 1 image processing requests	X	
3.2.1.3	Data availability notification	X	
3.2.1.4	Production status requests <b>NOTE:</b> This requirement to be deleted.		
3.2.1.5	Product cancellation requests <b>NOTE:</b> This requirement to be deleted.		
3.2.1.6	Product problem report (trouble ticket)		X
3.2.2	The LPGS shall interface with the ECS to coordinate the transfer of the following:		
3.2.2.1	LPGS L1 digital images	X	
3.2.2.2	Processing status <b>NOTE:</b> This requirement to be deleted		
3.2.2.3	Production quality and accounting information <b>NOTE:</b> This requirement to be deleted.		
3.2.2.4	L1 processing statistics <b>NOTE:</b> This requirement to be deleted.		
3.2.2.5	L1 metadata	X	
3.2.2.6	PCD file (consensus)	X	
3.2.2.7	MSCD file (consensus)	X	
3.2.2.8	IC data file	X	
3.2.2.9	CPF	X	
3.2.2.10	Geolocation table	X	

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Requirement Number	Requirement Description	Release 1	Release 2
3.2.3	The LPGS shall interface with the Image Assessment System (IAS) to provide Level 1 radiometric characterization data.		X
3.2.4	The LPGS shall interface with the Data Handling Facility (DHF) to provide Level 1 processing anomaly reports <b>NOTE:</b> This requirement to be deleted.		
3.3	Functional Requirements		
3.3.1	Retrieve LOR Files		
3.3.1.1	The LPGS shall provide the capability to receive LOR data inputs from the ECS. This data shall include the following items:		
3.3.1.1.1	Level 1 image processing request that includes the following:		
3.3.1.1.1a	Selected coordinate reference system for map projection	X	
3.3.1.1.1b	Requested orientation (nominal path or north up)	X	
3.3.1.1.1c	Variable grid cell size selection	X	
3.3.1.1.1d	Output format selection	X	
3.3.1.1.1e	Resampling filter	X	
3.3.1.1.1f	Selected band(s)	X	
3.3.1.1.1g	Selected scene or subinterval identification	X	
3.3.1.1.1h	L1R or L1G image processing selection	X	
3.3.1.1.1i	Geographic area	X	
3.3.1.1.1j	WRS (path/row) scene identifier	X	
3.3.1.1.1k	Internal calibrator (IC) or calibration parameter file (CPF) (default = CPF)	X	
3.3.1.1.2	Data availability notification specifying the location of associated LOR product files ready for transfer	X	
3.3.1.1.3	LOR product files [includes LOR image data, PCD, MSCD and associated calibration files (internal calibrator and calibration parameter files)]	X	
3.3.1.1.4	Production status request <b>NOTE:</b> This requirement to be deleted.		
3.3.1.1.5	Product cancellation request <b>NOTE:</b> This requirement to be deleted.		
3.3.1.1.6	Product problem report (trouble ticket)	X	
3.3.1.2	The LPGS shall provide the capability to create and send LOR product requests to the ECS.	X	
3.3.1.3	The LPGS shall coordinate resolution of data transfer problems with any LOR product file with ECS.		
3.3.1.3.1	The LPGS shall be able to detect data transfer problems.	X	

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Requirement Number	Requirement Description	Release 1	Release 2
3.3.1.3.2	The LPGS shall be able to reorder data.	X	
3.3.2	Generate L1R Digital Images. The LPGS shall be able to extract and process Landsat 7 ETM+ Earth image data from the L0R Earth image data file to produce radiometrically corrected L1R digital images.		
3.3.2.1	The LPGS shall be able to extract and process attitude and ephemeris data from the L0R PCD files.	X	
3.3.2.2	The LPGS shall be able to extract parameters from the L0R internal calibrator or calibration parameter file for use in L1R and L1G processing.	X	
3.3.2.3	The LPGS shall be able to generate gains and biases from either the internal calibrator data or from the calibration parameter file. The default shall be the calibration parameter file.	X	
3.3.2.4	The LPGS shall be able to extract and process mirror scan correction coefficients from the L0R MSCD file to determine scan line quality.	X	
3.3.2.5	The LPGS shall be capable of detecting the following image artifacts:		
3.3.2.5.1	Striping	X	
3.3.2.5.2	Banding	X	
3.3.2.5.3	Coherent noise	X	
3.3.2.5.4	Deleted		
3.3.2.5.5	Scan correlated shift	X	
3.3.2.5.6	Saturated detectors	X	
3.3.2.5.7	Dropped scan lines	X	
3.3.2.6	The LPGS shall be capable of characterizing the following image artifacts:		
3.3.2.6.1	Striping	X	
3.3.2.6.2	Banding	X	
3.3.2.6.3	Coherent noise	X	
3.3.2.6.4	Deleted		
3.3.2.6.5	Deleted		
3.3.2.6.6	Saturated detectors	X	
3.3.2.6.7	Dropped scan lines	X	
3.3.2.7	The LPGS shall be capable of applying compensation for the following image artifacts:		
3.3.2.7.1	Striping	X	
3.3.2.7.2	Banding	X	
3.3.2.7.3	Coherent noise	X	
3.3.2.7.4	Memory effect	X	
3.3.2.7.5	Scan correlated shift	X	
3.3.2.7.6	Inoperable detectors	X	

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Requirement Number	Requirement Description	Release 1	Release 2
3.3.2.7.7	Saturated detectors	X	
3.3.2.7.8	Dropped scan lines	X	
3.3.2.8	The LPGS shall be capable of applying compensation for gain changes within a requested Level 1 scene or subinterval as identified in the Level 0R metadata.	X	
3.3.2.9	The LPGS shall be capable of producing L1R data from L0R data for both the ascending and descending portions of the Landsat 7 orbit.	X	
3.3.2.10	The LPGS shall be able to produce L1R digital images for any combination of the eight spectral channels.	X	
3.3.2.11	The LPGS shall assemble and append to the L1R digital images all of the applicable metadata, quality and accounting data gathered in the construction of the L1R digital image. The complete L1R digital image package contains the following data elements as		
3.3.2.11.1	Level 1R digital image (all requested bands)	X	
3.3.2.11.2	Level 1 metadata file	X	
3.3.2.11.3	Deleted		
3.3.3	Generate L1G Digital Images. The LPGS shall be able to extract and process Landsat 7 ETM+ Earth image data from the L1R Earth image data files to produce systematically corrected L1G digital images.		
3.3.3.1	The LPGS shall have the capability to resample L1R digital images and apply the following map projections:		
3.3.3.1.1	Space Oblique Mercator	X	
3.3.3.1.2	Universal Transverse Mercator (UTM)	X	
3.3.3.1.3	Lambert Conformal Conic	X	
3.3.3.1.4	Transverse Mercator	X	
3.3.3.1.5	Oblique Mercator	X	
3.3.3.1.6	Polyconic	X	
3.3.3.1.7	Polar Stereographic	X	
3.3.3.2	The LPGS shall support the following compensation resampling methods:		
3.3.3.2.1	Nearest neighbor	X	
3.3.3.2.2	Cubic convolution	X	
3.3.3.2.3	Modulation Transfer Function (MTF)	X	
3.3.3.3	The LPGS shall have the capability to produce L1G digital images with the following grid cell characteristics:		
3.3.3.3.1	The grid cell size is variable from 15 M to 60 M in .001 M increments	X	
3.3.3.3.2	The grid cell size is independently variable between spectral bands.	X	

## REVIEW

Requirement Number	Requirement Description	Release 1	Release 2
3.3.3.4	The LPGS shall produce L1G digital images that are spatially continuous between contiguous partial subintervals or WRS scenes	X	
3.3.3.5	The LPGS shall have the capability to generate L1G digital images oriented by the following:		
3.3.3.5.1	Nominal path	X	
3.3.3.5.2	North up	X	
3.3.3.6	The LPGS shall be capable of producing L1G data from L0R data for both the ascending and descending portions of the Landsat 7 orbit.	X	
3.3.3.7	The LPGS shall be able to produce L1G digital images for any combination of the eight spectral channels.	X	
3.3.3.8	The LPGS shall assemble and append to the L1G digital images all of the applicable metadata, quality and accounting data gathered in the construction of the L1G digital image. The complete L1G digital image package contains the following data elements as		
3.3.3.8.1	Level 1G digital image (all requested bands)	X	
3.3.3.8.2	Level 1 metadata file	X	
3.3.3.8.3	Deleted		
3.3.4	Generate Level 1 metadata file		
3.3.4.1	The LPGS shall generate ancillary L1R digital image data that describes the contents, processing parameters, and quality indicators of the L1R digital image.	X	
3.3.4.2	The LPGS shall generate ancillary L1G digital image data that describes the contents, processing parameters, and quality indicators of the L1G digital image.	X	
3.3.4.3	The LPGS shall generate and append processing summary indicators specifying the algorithms applied to the Level 1 digital images.	X	
3.3.5	Assess Level 1 digital image quality		
3.3.5.1	The LPGS shall support automatic assessment of Level 1 digital image quality.		X
3.3.5.2	The LPGS shall be able to optionally display any single band of the L1R digital image for visual quality assessment.		X
3.3.5.3	The LPGS shall be able to optionally display any single band of the L1G digital image for visual quality assessment.		X
3.3.5.4	The LPGS shall be able to optionally print a color hard copy of the display of any band(s) of the L1R digital image for visual quality assessment		X



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Requirement Number	Requirement Description	Release 1	Release 2
3.3.5.5	The LPGS shall be able to optionally print a color hard copy of the display of any band(s) of the L1G digital image for visual quality assessment.		X
3.3.6	Transfer Level 1 file(s)		
3.3.6.1	The LPGS shall be able to output Level 1 digital images in the following formats:		
3.3.6.1.1	HDF-EOS (L1R and L1G)	X	
3.3.6.1.2	EOSAT FAST (L1G only)		X
3.3.6.1.3	GeoTIFF (L1G only)	X	
3.3.6.2	The LPGS shall transfer L1 files to ECS per the ECS to LPGS ICD.	X	
3.3.6.3	The LPGS shall provide the capability to display LPGS Level 1 file transfer summary upon operator request.		X
3.3.6.4	The LPGS shall be able to detect files which have been successfully transferred.	X	
3.3.6.5	The LPGS shall be able to mark successfully transferred files as candidates for deletion from LPGS temporary storage.		X
3.3.7	Data Storage		
3.3.7.1	The LPGS shall be able to provide temporary online storage for the equivalent of 3 days of completed products <b>NOTE:</b> Wording of this requirement to be modified.		X
3.3.7.2	The LPGS shall be able retransmit files located in temporary storage.	X	
3.3.7.3	The LPGS shall be able to store Level 1 processing information online for 90 days.		X
3.3.7.4	The LPGS shall be able to transfer Level 1 processing information to offline storage after 90 days.		X
3.3.7.5	The LPGS shall be able to recover, display, and print Level 1 processing information located on offline storage for the life of the mission.		X
3.3.8	Control LPGS Operations		
3.3.8.1	The LPGS shall allow the operator to select thresholds for statistics and errors reported by the LPGS.		X
3.3.8.2	The LPGS shall automatically generate messages and alarms to alert the operator of LPGS results and errors exceeding operator-selected thresholds.		X
3.3.8.3	The LPGS shall generate intermediate processing summaries on a periodic basis according to operator specification.		X
3.3.8.4	The LPGS shall provide an option to display Level 1 digital image quality status and statistics at operator request.		X

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Requirement Number	Requirement Description	Release 1	Release 2
3.3.8.5	The LPGS shall provide an option to print Level 1 digital image quality status and statistics at operator request.		X
3.3.8.6	The LPGS shall provide the capability to manually override the LPGS automated processing functions.		X
3.3.8.7	The LPGS shall provide the manual capability to cancel Level 1 processing prior to completion of digital image generation.		X
3.3.8.8	The LPGS shall be able to display and print trouble tickets received from ECS.	X	
4	LPGS Performance Requirements		
4.1	Performance Requirements		
4.1.1	The LPGS shall be capable of processing a volume of data equivalent to 28 (accounts for 10 percent LPGS internal reprocessing) standard L0R WRS scenes to Level 1 digital images each day.		X
4.1.2	The LPGS shall contribute no greater than 0.7 percent uncertainty to absolute radiometric accuracy during the generation of L1R and L1G digital images.		X
4.1.3	The LPGS shall contribute circular errors no greater than 1.8 m, 1 sigma, in the production of systematically corrected L1G digital images.		X
4.1.4	The LPGS shall provide at least 110 percent of the processing throughput capability required to satisfy the worst case processor loading.		X
4.1.5	The LPGS shall provide at least 125 percent of the random access memory capacity required to satisfy the worst case memory loading.		X
4.1.6	The LPGS shall provide at least 125 percent of the peripheral storage capacity required to satisfy the worst case peripheral storage loading.		X
4.1.7	Deleted		
4.1.8	The LPGS shall produce Level 1G products that are accurate to within 250 meters cross track and 250 meters along track using geometric calibration information generated by IAS and contained in the associated calibration parameter file.		X
4.1.9	NEW REQUIREMENT TO BE ADDED: Register pixels from one spectral band to the corresponding pixels.	X	
4.2	External Interface Performance Requirements		
4.2.1	The LPGS shall be able to ingest from ECS a data volume equivalent to three WRS scenes worth of standard L0R data for each Level 1 digital image request.	X	
4.2.2	The LPGS shall have the capability to support the transfer to ECS of the equivalent of a minimum of 25 WRS sized Level 1 digital images per day.		X

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Requirement Number	Requirement Description	Release 1	Release 2
4.2.3	The LPGS-ECS interface shall provide the capability to transfer to the ECS at least 33 GB of Level 1 output files per day.		X
4.3	Reliability, Maintainability, and Availability		
4.3.1	The LPGS shall provide an operational availability of 0.96 (TBR).		X
4.3.2	The LPGS shall support a mean time to restore (MTTR) capability of 4 hours (TBR).		X
4.4	Security		
4.4.1	The LPGS shall provide system, network, and operations security according to the ESDIS security policy (Reference 7) and the NASA AIS Handbook (Reference 8).		X

## REVIEW

# Appendix B. Development Area Lines of Code Estimates

Table B-1 reflects the lines of code estimate for each LPGS release. Table B-2 reflects the new and re-use estimates for each release. LPGS re-uses code from IAS and LPS.

**Table B-1. LPGS Lines of Code Estimate by Release**

Subsystem	Est LOC	R1	R2
User interface (UI)	8000	2600	5400
Process control subsystem (PCS)	2700	2100	600
Data management subsystem (DMS)	12130	9290	2840
Quality assessment subsystem (QAS)	2400	1800	600
Anomaly analysis subsystem (AAS)	2500	1500	1000
Radiometric processing subsystem (RPS)	24000	24000	-
Geometric processing subsystem (GPS)	39000	39000	-
Globals	4895	4570	325
Database	10235	9860	375
Diagnostic and test	3500	2900	600
Grand total	109360	97620	11740

**Table B-2. Estimated Reuse per Release**

Subsystem	R1		R2	
	New	Reuse	New	Reuse
User interface (UI)	2600	-	3400	2000
Process control subsystem (PCS)	1400	700	600	-
Data management subsystem (DMS)	4890	4400	2340	500
Quality assessment subsystem (QAS)	1800	-	600	-
Anomaly analysis subsystem (AAS)	500	1000	500	500
Radiometric processing subsystem (RPS)*	-	24000	-	-
Geometric processing subsystem (GPS)*	-	39000	-	-
Globals	20	4550	325	-
Database	3960	5900	325	50
Diagnostic and test	900	2000	600	0
Total	16070	81550	8690	3050
Total per release	97620		11740	
Grand total	109360			

\* RPS and GPS are black boxes to LPGS. Software development only has to integrate the subsystems into LPGS.

## REVIEW

### Appendix C. Mapping of Modules to Releases

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**Table C-1. Mapping of Process Control Subsystem Modules to Releases**

Module Name	R1	R2
psi_Init	100%	
psi_Main	100%	
psi_ProcDir	100%	
psi_ReapChild	100%	
psi_StartProcess	100%	
pwc_init	25%	75%
pwc_main	50%	50%
pwc_MonitorScript	100%	
pwc_proc_completed_wo	25%	75%
pwc_proc_success_script_stat	25%	75%
pwc_StartNextScript	100%	
pwg_determine_wo_proc	100%	
pwg_gen_wo	100%	
pwg_gen_wo_dir	100%	
pwg_init	100%	
pwg_main	100%	
pws_chk_child_term	100%	
pws_create_work_orders	100%	
pws_init	75%	25%
pws_main	70%	30%
pws_proc_resumable_wo	50%	50%
pws_proc_startable_wo	50%	50%
pws_start_wo_execution	50%	50%
pws_term	50%	50%

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**Table C-2. Mapping of Data Management Subsystem Modules  
to Releases (1 of 4)**

Module Name	R1	R2
dfi_assemble_l1g_prod	100%	
dfi_assemble_l1r_prod	100%	
dfi_check_completeness	100%	
dfi_convert_l1g	100%	
dfi_format_l1	100%	
dfi_init	100%	
dfi_l1g_image_to_fast		100%
dfi_l1g_image_to_geotiff	100%	
dfi_l1g_image_to_hdf	100%	
dfi_l1g_meta_to_fast		100%
dfi_l1g_meta_to_geotiff	100%	
dfi_l1r_image_to_hdf	100%	
dfi_main	100%	
dfi_meta_to_hdf	100%	
dfi_pack_l1	100%	
dgr_calc_timer		100%
dgr_clear_current_stats		100%
dgr_collect_stats		100%
dgr_format_stats		100%
dgr_gen_stat_rpt		100%
dgr_get_current_stats		100%
dgr_if_with_ias		100%
dgr_init		100%
dgr_main		100%
dgr_terminate		100%
did_CalculateCaptureDirection		100%
did_CalculateTempFit		100%
did_createDDR		100%
did_CreateReport		100%
did_fixPCDTime		100%
did_GetCPFValidationInfo	100%	
did_IngestMSCD	100%	
did_IngestPCD	100%	
did_IngestStatus	100%	
did_PreProcess	100%	
did_UpdateMSCD	100%	
did_UpdatePCD	100%	
did_ValidateADS	100%	
did_ValidateAttitude	100%	

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**Table C-2. Mapping of Data Management Subsystem Modules  
to Releases (2 of 4)**

Module Name	R1	R2
did_ValidateCalData	100%	
did_ValidateCPF	100%	
did_ValidateEphemeris	100%	
did_ValidateFHS_SHSError	100%	
did_ValidateGeo	100%	
did_ValidateGyro	100%	
did_ValidateGyroDrift	100%	
did_ValidateHDFDir	100%	
did_ValidateInstrumentOnTime	100%	
did_ValidateLineLength	100%	
did_ValidateMSCD	100%	
did_ValidatePCD	100%	
did_ValidateScanDirection	100%	
did_ValidateScanStartTime	100%	
did_ValidateScene	100%	
did_ValidateSceneData	100%	
did_ValidateSLO	100%	
did_ValidateTemp	100%	
did_ValidateTimeCorrection	100%	
die_create_response	100%	
die_eval_urf	100%	
die_format_data	100%	
die_init	100%	
die_insert_prod_req	100%	
die_main	100%	
die_poll_for_pdr	100%	
die_prepare_responses	100%	
die_process_cancel		100%
die_send_response	100%	
die_term	100%	
dil_build_daa	100%	
dil_build_data_req	100%	
dil_build_ddn	100%	
dil_calc_timer	100%	
dil_check_criteria	100%	
dil_close_session	100%	
dil_close_socket	100%	
dil_create_file_msg	100%	
dil_create_prod_dir	100%	

## REVIEW

**Table C-2. Mapping of Data Management Subsystem Modules  
to Releases (3 of 4)**

Module Name	R1	R2
dil_delete_file_msg	100%	
dil_do_daa	100%	
dil_do_dan	100%	
dil_do_dda	100%	
dil_do_ddn	100%	
dil_do_user	100%	
dil_ftp_ecs_msg	100%	
dil_ftp_get_file	100%	
dil_ftp_put_file	100%	
dil_init	100%	
dil_main	100%	
dil_move_data	100%	
dil_open_socket	100%	
dil_poll	100%	
dil_proc_ack	100%	
dil_proc_dan	100%	
dil_read_msg	100%	
dil_req_l0r	100%	
dil_send_close_msg	100%	
dil_send_ecs_msg	100%	
dil_send_start_msg	100%	
dil_stage_l0r	100%	
dil_start_session	100%	
dil_term	100%	
dil_transfer_l0r	100%	
dil_val_vs_dan	100%	
dil_validate_dan	100%	
dil_validate_dda	100%	
dil_validate_l0r	100%	
dil_xmit_msg	100%	
dpl_copy_save_to_input	100%	
dpl_init	100%	
dpl_main	100%	
drm_chk_disk		100%
drm_chk_disk_usage		100%
drm_clean_up_disk		100%
drm_init		100%
drm_main		100%



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***Table C-2. Mapping of Data Management Subsystem Modules to Releases (4 of 4)***

Module Name	R1	R2
drm_proc_user_input		100%
drm_recursive_deletion		100%
dxl_create_pdr	100%	
dxl_delete_protocol_files	100%	
dxl_init	100%	
dxl_main	100%	
dxl_poll_for_response	100%	
dxl_prepare_pdr	100%	
dxl_process_pan	100%	
dxl_process_pdrd	100%	
dxl_read_response	100%	
dxl_term	100%	

***Table C-3. Mapping of Radiometric Processing Subsystem Modules to Releases***

Unit Name	R1	R2
TBS		

***Table C-4. Mapping of Geometric Processing Subsystem Modules to Releases***

Unit Name	R1	R2
TBS		

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***Table C-5. Mapping of Quality Assessment Subsystem Modules to Releases***

Module Name	R1	R2
q1g_init	100%	
q1g_main	100%	
q1g_processing	100%	
q1g_term	100%	
q1r_init	100%	
q1r_main	100%	
q1r_processing	100%	
q1r_term	100%	
qui_main		100%
qui_print_reports		100%
qui_view_reports		100%

***Table C-6. Mapping of Anomaly Analysis Subsystem Modules to Releases***

Unit Name	R1	R2
TBS		

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**Table C-7. Mapping of Globals to Releases (1 of 2)**

Module Name	R1	R2
xxx_BuildWOParmODL	100%	
xxx_ConnectToDB	100%	
xxx_CreateEvent	100%	
xxx_db_ConnectToDatabase	100%	
xxx_db_DisconnectFromDatabase	100%	
xxx_db_PutEventLog	100%	
xxx_DisconnectFromDB	100%	
xxx_display_output		100%
xxx_FileLock	100%	
xxx_get_task_config	100%	
xxx_get_user_input	100%	
xxx_GetODLField	100%	
xxx_GetParam	100%	
xxx_GetTime	100%	
xxx_Handler	100%	
xxx_HDF library units to write MSCD update	100%	
xxx_HDF library units to write PCD update	100%	
xxx_ipc_accept	100%	
xxx_ipc_close	100%	
xxx_ipc_clr	100%	
xxx_ipc_isset	100%	
xxx_ipc_read	100%	
xxx_ipc_select	100%	
xxx_ipc_set	100%	
xxx_LogError	100%	
xxx_OpenODL	100%	
xxx_Parse ODL using ODL Library	100%	
xxx_print_image		100%
xxx_proc_cancel_req		100%
xxx_Put_db_Activity	100%	
xxx_PutEvent	100%	
xxx_PutEventLog	100%	
xxx_Read and Write DDR using HDF Library	100%	
xxx_Read Calibration using HDF Library	100%	
xxx_Read Geo using HDF Library	100%	
xxx_Read HDF Directory using HDF Library	100%	
xxx_Read MSCD using HDF library	100%	
xxx_Read ODL using HDF Library	100%	
xxx_Read PCD using HDF library	100%	

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**Table C-7. Mapping of Globals to Releases (2 of 2)**

Module Name	R1	R2
xxx_Read Scene using HDF Library	100%	
xxx_Read SLO using HDF Library	100%	
xxx_ReadDAACMetadata	100%	
xxx_ReadGeo	100%	
xxx_ReadHDFDirectory	100%	
xxx_ReadMetadata	100%	
xxx_ReadMSCD	100%	
xxx_ReadPCD	100%	
xxx_ReadSLO	100%	
xxx_show_image		100%
xxx_Signal	100%	
xxx_StartProcess	100%	
XXX_Unlock	100%	
xxx_WRITELOCK	100%	

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**Table C-8. Mapping of Database Modules to Releases (1 of 2)**

Module Name	R1	R2
dadb_catalog_l0r	100%	
dadb_delete_trend_data		100%
dadb_find_prod_req	100%	
dadb_get_next_prod	100%	
dadb_get_next_xmit	100%	
dadb_get_pr_to_del		100%
dadb_get_stats_from_db		100%
dadb_write_stats_to_db		100%
padb_check_wo_script_pause	100%	
padb_get_l0ready_prod_req	100%	
padb_get_next_resumable_wo	100%	
padb_get_next_startable_wo	100%	
padb_get_num_started_wo	100%	
padb_get_req_info	100%	
padb_get_script_params	100%	
padb_GetDirective	100%	
padb_GetStartableScript	100%	
padb_link_wo_to_scripts	100%	
padb_setup_wo_parms	100%	
padb_UpdateWOState	100%	
xadb_check_cancel_stat		100%
xadb_create_wo_log	100%	
xadb_get_prod_dir	100%	
xadb_get_prod_req	100%	
xadb_get_prod_req_id	100%	
xadb_get_task_config	100%	
xadb_get_time_period	100%	
xadb_GetCPFValidation	100%	
xadb_GetDBMSLogin	100%	
xadb_GetIASConfig		100%
xadb_GetIngestParameters	100%	
xadb_GetScriptParms	100%	
xadb_insert_wo	100%	
xadb_Insert0RTrending	100%	
xadb_PutEventLog	100%	
xadb_store_wo_dir	100%	
xadb_update_pr	100%	
xadb_upd_cancel_flag		100%
xadb_upd_prod_req_del_flag		100%

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***Table C-8. Mapping of Database Modules to Releases (2 of 2)***

Module Name	R1	R2
xdb_update_prod_req_state	100%	
xdb_upd_tbd1_prflag	100%	
xdb_upd_tbd2_prflag	100%	

***Table C-9. Mapping of Other Tasks to Releases***

Unit Name	R1	R2
TBS		

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### Abbreviations and Acronyms

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AAS	anomaly analysis subsystem
AGR	AAS Generate Reports Task
AIT	Algorithm Implementation Team
AMA	AAS Manage Anomalies Task
APR	AAS Perform Anomaly Runs Task
ARD	AAS Retrieve LPGS Data Task
ATA	AAS Transmit Anomalies Task
AUI	analyst user interface
CNMOS	Consolidated Network Management and Operations Support
COTS	commercial off-the-shelf
CPF	calibration parameter file
DAAC	Distributed Active Archive Center
DHF	Data Handling Facility
DMS	data management subsystem
ECS	EOSDIS Core System
EDC	EROS Data Center
EDC DAAC	Distributed Active Archive Center at EDC
EGS	EOS Ground System
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EROS	Earth Resources Observation System
ESDIS	Earth Science Data and Information System
ETM+	Enhanced Thematic Mapper Plus
FAST-C	Fast Argonne System for Transport, Format C
FIFO	first in, first out
GB	gigabyte
GeoTIFF	Geographic Tag(ged) Image File Format

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GPS	geometric processing subsystem
GSFC	Goddard Space Flight Center
GTSIM	Generic Telemetry Simulator
H/STX	Hughes STX
HDF	Hierarchical Data Format
IAS	Image Assessment System
IC	internal calibrator
Landsat 7	Land Satellite 7
LOC	lines of code
LPGS	Level 1 Product Generation System
LPS	Landsat Processing System
MO&DSD	Mission Operations and Data Systems Directorate
MOC	Mission Operations Center
MOSDD	Mission Operations and System Development Division
MSCD	mirror scan correction data
MTF	modulation transfer function
MTTR	mean time to restore
NASA	National Aeronautics and Space Administration
OUI	operator user interface
PCD	payload correction data
PCS	process control subsystem
QAS	quality assessment subsystem
RPS	radiometric processing subsystem
TBS	to be supplied
UI	user interface
UTM	Universal Transverse Mercator
WRS	Worldwide Reference System